PNEUMATIC ACTUATOR

Reference to Related Application

[0001] This is a formal application based on and claiming the benefit of United States provisional patent application no. 60/433,764, filed December 17, 2002

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to actuators.

[0003] More particularly, the invention provides an alternative to high-pressure hydraulic cylinders, by providing a device which provides similar performance using a low pressure fluid (typically air). A particular application is a clamping device, including a collet, but the invention is not necessarily limited to that application. More broadly, the invention relates to the actuator, regardless of what is actuated.

Description of the Prior Art

[0004] The invention is a novel adaptation of a pneumatic "muscle" produced by Festo AG & Co., among others. The muscle is of the type described generally in United States patent no. 6,349,746, for example, and operates by what has been referred to as the "Chinese finger puzzle" principle. According to this principle, a tube is pneumatically expanded radially, and as it expands radially, its length contracts. The axial force produced in such an "air muscle" is at a maximum at full muscle extension and decreases as the muscle is allowed to shorten.

[0005] Air muscles offer a number of advantages, including low cost, flexibility, compliance, smooth operation, a high power-to-weight ratio, ample power (especially when retracting from full extension), and inherent damping since the forces decrease as the muscle contracts and thus speed tends to zero.

SUMMARY OF THE INVENTION

[0006] In view of the above, it is an objective of this invention to provide an actuator which employs a fluid muscle of the general type described in United States patent no. 6,349,746, hereby incorporated by reference. Although the fluid used will

be air in the vast majority of situations, and although the preferred embodiment uses air, it should be understood that other fluids could be used if desired, and accordingly the term "fluid muscle" is used throughout this specification, instead of the more specific term "air muscle". However, in most cases, the fluid muscle will in fact be an air muscle.

[0007] Accordingly, in the invention, the actuator has an outer housing, and a fluid muscle mounted within the outer housing, defining an annulus between the fluid muscle and the outer housing. The fluid muscle has a first end and a second end retractable relative to the first end. Fluid supply means are connected for separately pressurizing the fluid muscle and the annulus to a pressure above ambient pressure. Thus, releasing pressure from the annulus, for example by venting to ambient pressure, causes the fluid muscle to contract, thereby producing actuation movement of the second end.

[0008] In usual applications of air muscles, the air around the muscle is at ambient pressure, and the muscle is pressurized to expand it radially. In the preferred embodiment of the invention, an outer housing is provided, and both the interior of the muscle and the annulus around the muscle between the muscle and the outer housing are pressurized, for example to standard line pressure of 80 psi. The muscle is activated by venting (depressurizing) the annulus. This has several advantages over the prior art uses of air muscles, including higher peak axial forces and protection of the muscle from external damage.

[0009] The actuation movement of the second end can be used in virtually any desired manner. In an exemplary application, that movement is used to operate a collet.

[0010] Further details of the invention will be described or will become apparent in the course of the following detailed description.

[0011] Use of the invention allows the elimination of high-pressure hydraulics in an automation system, which has significant advantages in terms of cost, complexity and maintenance. Use of the invention for a collet clamp is one particular application.

[0012] Previously, in order to generate large clamping forces in collets, hydraulic actuators had to be incorporated to keep devices reasonably compact and still generate high clamping forces. Standard air cylinders can produce the forces required but they tend to be very large and cumbersome. By using this invention, the device can produce the forces required in a compact package, and problems related to the use of hydraulics are eliminated. Many manufacturers which presently use hydraulically activated clamping devices will easily be persuaded to switch to a device which operates on clean air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a side cross-sectional view of a preferred embodiment of the actuator, showing its use to actuate a collet;

Fig. 2 is a cross-sectional view corresponding to Fig. 1, with the assembly rotated 90 degrees about its axis; and

Fig. 3 is a perspective view of the assembly.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The invention will now be described in greater detail, with reference to the accompanying drawings.

[0015] A tubular fluid muscle **1**, preferably an air muscle of the general type referred to above, is clamped at one end between a preferably tapered axially-oriented opening in a stationary outer housing **2** and a preferably tapered end plug **4**, which is held in place by a threaded insert **5**, snap ring or other like means. The outer housing has a chamber or annulus **10**, preferably but not necessarily cylindrical, in which a moveable piston **12** is positioned in a sealed relationship with the annulus (with a seal **14** in a groove **15** of the piston, for example). The muscle membrane is stretched past its static rest length by the movable piston.

[0016] The distal (moving) end **18** of the muscle is clamped between a preferably tapered axially-oriented opening in the piston and a second preferably tapered plug **20**, which is secured in the piston by a threaded nut **21**. There is thus an inner chamber **22** inside the muscle, and an outer chamber, i.e. the annulus **10** between the muscle and the outer housing. Air ports **24**, **25** are provided in the outer housing and/or end plug to allow air to be introduced into or vented from the inner and outer chambers independently. Preferably there are several air ports **25** from the annulus, for enhanced speed in venting the annulus to ambient air.

[0017] An exemplary use of the actuator is with a collet **30**. A collet extension **31** is threaded into the piston plug **20**, the threads providing length adjustment, and extends out the distal end of the unit, through a collet support structure **33** secured across the end of the unit. The collet support structure includes an end cap portion

34 which closes the end of the outer housing **2** and acts as a stop for the piston **12** at a position corresponding to the maximum desired extension of the fluid muscle. Orientation pins **35** and **36** riding in slots **37** and **38** in the collet support and collet extension prevent the collet extension from rotating once screwed in to the desired overall length for the particular intended application. Within the collet **31**, there is preferably a spring **40** which biases and ejector pin **42** forwardly (guided by a bushing **43**) to eject a workpiece from the collet on completion of an operation and opening of the collet. Obviously, this is an optional feature which does not relate to the actuator itself.

[0018] To extend (open) the collet, both the inner and outer chambers are pressurized, which forces the piston towards the distal end, stretching the muscle to its limit and simultaneously causing the collet to move forward and open.

[0019] To retract (close) the collet, the outer chamber **10** is de-pressurized, which forces the muscle to expand radially into the outer chamber and simultaneously shorten axially. The piston **12**, being clamped to the distal end of the muscle, then pulls the collet backwards in the support structure **34**, causing its distal end **48** to deflect radially inwardly in conventional fashion to clamp tightly on any appropriately placed object.

[0020] Many variations on the preferred embodiment described above are conceivable within the scope of the invention. For example, there could be many variations in the details of how the ends of the fluid muscle are clamped. Similarly, there could be many variations in how the movement produced by venting could be taken advantage of, both in terms of end use of the movement and in terms of how a moving element (such as the collet extension **31**) could be attached and guided.